FOREST PEST MANAGEMENT
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EVALUATION OF DISEASES IN THE BASKET AND TAMARACK II TIMBER SALE AREAS, PINERIDGE RANGER DISTRICT, SIERRA NATIONAL FOREST

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At the request of Mark Smith, Sierra National Forest Silviculturist, I visited selected sites within the Basket and Tamarack II timber sale areas on October 20 and 21, 1992. The objectives were to: 1) identify diseases present in stands proposed for harvest, 2) determine potential impacts of these diseases on the sites, and 3) outline management alternatives. Ramiro Rojas, from the Pineridge District, provided site specific background information in the field and expressed the District's concerns regarding the timber sales.

BACKGROUND AND OBSERVATIONS

Both timber sales involved in this evaluation are scheduled for harvest in 1993. Sale areas vary from 5700 to 8000 feet in elevation and include mixed conifer, lodgepole pine, and red fir stands. Many clearcuts done in the 1970's were planted to Jeffrey pine and are now in poor condition. Many lodgepole pine stands are densely stocked because of natural regeneration. Pest impacts are a concern in addition to the spotted owl, summer and winter recreation use, soil protection, and visual constraints. In general, recent mortality present in the areas we visited seemed low compared to most Sierra Nevada mixed conifer forests.

Our disease evaluation focused on, but was not limited to, shelterwood units cut in the mid 1980's. These units still contain many merchantable trees while regeneration is generally poor. Any harvesting in 1993 will be done in unsuitable spotted owl habitat. Pathogens present in the sale areas are discussed below according to the tree species they affect. The biology of each pest mentioned is described at the end of this report.

True Fir:

Annosus root disease, caused by Heterobasidion annosum, was found on red fir at several locations within sites that received shelterwood cuts in 1986. Fresh conks growing inside stumps were used to confirm the disease. The overall impact of this pest was not immediately obvious because there was not a lot of current mortality in root disease centers. Older snags and windthrown trees were present and are typically found where H. annosum has been active in true fir stands. Based on the occurrence and distribution of this root disease throughout California true fir stands, we can assume that most, if not all, stands in the proposed sale areas that were previously logged have some root disease.

Red fir dwarf mistletoe (Arceuthobium f.sp. magnificae) was present throughout the stands we visited and at moderate to severe levels. Both overstory and understory trees were infested. Infection was heavy enough to contribute to tree mortality, usually in combination with engraver beetles and wood borers, and to reduce the life span of diseased trees. This subspecies of mistletoe does not affect white fir or any other conifer species, except noble fir. White fir was not abundant on the sites we saw, but what was present was mistletoe free.

Although total true fir mortality appeared low compared to many areas in the Sierra Nevada, the pattern and causes of mortality were similar. A major factor in most recent mortality is drought stress, which makes true fir more vulnerable to pests such as the **fir engraver** (Scolytus ventralis) and **roundheaded wood borer** (Tetropium abietis). We did confirm that the fir engraver was present on recently killed and dying red fir. Trees with dwarf mistletoe are already under stress and tend to be the first ones that are attacked by insects and killed during periods of drought.

Cytospora canker (Cytospora abietis) was common and highly visible in areas with true fir. This is a disease of stressed or weakened trees and, not surprisingly, has become very prevalent on true fir during the past 6-year drought period. The causal fungus typically infects branches less than 4 inches in diameter, resulting in branch mortality or "flagging". The red "flags" are easily seen and used to diagnose the disease. However, the primary sites for infection are branches already parasitized by dwarf mistletoe. Dwarf mistletoe alone will rarely kill branches, but C. abietis seems to favor mistletoe swellings and, once established, will kill a branch rapidly.

The above combination of pests, all working together, is taking a significant toll on the red fir component. While mortality may not be excessive at this time, many individual green trees have lost a large portion of their live crowns. Whether or not these trees will recover from the effects of drought stress is uncertain.

Lodgepole pine:

We did not spend a lot of time examining lodgepole pine stands, but it was still evident that **lodgepole pine dwarf mistletoe** (Arceuthobium americanum) was well established in the sale areas. This species of mistletoe is limited to

lodgepole pine, but will occasionally attack ponderosa pine. Particularly dangerous are situations where heavily infected overstory trees are able to infect nearby understory pines. The unique explosive discharge mechanism of seeds enables dwarf mistletoes to spread rapidly from overstory to understory trees.

MANAGEMENT ALTERNATIVES

1. **No Action.**

Pest related damage will most likely continue at present levels or intensify without management. Specifically, top-kill and mortality associated with fir engraver activity may be expected to continue in both the overstory and the intermediate/suppressed true fir. Mortality levels may fluctuate somewhat from year-to-year, but through time, will be consistently higher than would be expected in managed stands. Annosus root disease centers will enlarge and regeneration within centers will probably die. New disease centers may be initiated through wounds or freshly cut stump tops; only true fir would be affected. Dwarf mistletoe in red fir will spread to other red fir and intensify in trees already infected. The long-term effect of dwarf mistletoe will be primarily growth reduction and presdisposition to fir engraver attacks. The Cytospora canker fungus will continue to infect and kill branches with dwarf mistletoe which effectively reduces the live crown and vigor of individual trees. This could be a factor in future tree mortality if live crown ratios become too low due to branch killing.

In summary, interactions among insects, diseases, and stand conditions will continue to cause mortality, top-kill, and dieback resulting in: (1), reduced tree/stand growth and vigor; (2), increased numbers of snags and downed woody material; (3), reduced stocking levels; (4), reduced structural diversity; (5), un-regulated openings; and (4), increased fuel loading. The impact or significance of these effects, whether positive or negative, depends upon the resource management objectives for the stands.

2. **Root Disease Management.**

Justifying control of annosus root disease is not always straightforward in true fir stands because it is difficult to accurately assess its exact distribution or impact. Trees may be infected but not show any obvious outward symptoms of disease. It is common to underestimate the amount of root disease in stands where true fir is affected. Several control options are feasible.

a. **Borax treatment.** Treating freshly cut stumps with borax will prevent new disease centers from starting, but has no effect on established centers. While many National Forests routinely use borax when harvesting pine stands, application in true fir sites is often questioned because of the difficulty in assessing exactly how much disease is established before harvest. Borax is biologically effective

in preventing true fir stump infection, but we cannot determine the exact benefit of treatment in terms of dollars or stand productivity.

b. **Favor resistant species.** The form of H. annosum ("S" type) present will only infect true firs and possibly giant sequoia. Pines, incense-cedar, and hardwoods are not hosts for this type. Favoring or planting these resistant species is appropriate especially within or near identified or suspected root disease sites.

c. **Isolate known disease centers.** Removing all red fir within a 50-75 foot zone around the perimeter of disease centers may isolate the fungus and stop its spread into the stand. All cut stumps would have to be treated with borax. This procedure is based on our understanding of disease spread and biology, but has not been proven to be effective in California. The treatment would certainly increase the size of openings caused by root disease which could then be replanted with pines, incense cedar, or hardwoods.

3. **Dwarf Mistletoe Management.**

The two dwarf mistletoes most prevalent are on red fir and lodgepole pine. These mistletoes are different species and will not cross over to other conifers. Life cycles, biology, and control for each mistletoe are similar but there are distinct differences in management which are described below:

A. Clearcut and regenerate. This is an effective treatment for any tree species used mainly in stands where the dwarf mistletoe has built up to high levels and the majority of trees are infected. Generally, stands that have an average Hawksworth rating of 3 or more do not benefit from treatments other than clearcutting. By removing all hosts we eliminate this obligate parasite. The placement of clearcut boundaries is important in order to reduce the chances of dwarf mistletoe moving back into the regeneration unit. Use natural barriers such as roads, meadows, or areas with non-host trees.

B. Sanitation thinning. In PINES the heaviest infected trees are removed and the basal area is reduced to stimulate growth. This reduces high risk trees and overall stand infection, and increases the growth of residuals, which on good sites will allow the host to outgrow the infection. It is not necessary to eliminate all mistletoe infection.

When pre-commercially thinning PINE plantations one of the two methods below can be used to identify leave trees:

Crop Tree DBH in Inches	Maximum Dwarf Mistletoe Rating Tolerated
1 - 2	0
3 - 4	1
5 - 6	2
7+	3

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1. Trees less than 2" dbh: no infections

2. Trees more than 2" dbh: (Follow the order below for crop trees)

   1-Dom and co-dom trees with NO INFECTIONS.
   2-Dom and codom trees, DM in lower 1/3 crown.
   3-Dom and codom trees, DM in lower 1/2 crown.
   and less than 50% of the branches infected.
   4-Intermediate trees with NO INFECTIONS.

TRUE FIR stands, assuming there is no source of overstory infection, can be thinned without regarding or targeting infected trees. If these stands are managed to sustain good height growth, trees will outgrow the mistletoe because it moves very slowly upwards through the crowns of true firs.

C. **Removal of infected residuals.** In many stands for many reasons, infected residuals remain in a young stand. Removal of these trees is extremely important to prevent the gradual destruction of young stands around them and should be a high priority. Many of the most severely infected stands we see now in California are the result of past logging practices where infected trees were ignored and left in regeneration units throughout the life of the stand. In seed tree and shelterwood cuts, remove infected overstory trees within 10 years from planting and sanitize the young stand.

D. **Change in species composition.** Because mistletoes are host specific, we can alter the species composition in mixed stands to reduce or eliminate the long term impact from this pest. Standard silvicultural procedures during normal entries can be used to accomplish this treatment. This is one of the few dwarf mistletoe treatments that is practical in uneven aged stands.

E. **Pruning** infected branches is normally not economical in timber stands but is commonly used in recreation or administrative sites. Removing witches' brooms from high value trees can increase tree vigor and prolong the life of these individuals.

4. <u>Cytospora Canker Management.</u>

A. Probably the most effective control for Cystopora canker would be to prevent the establishment and buildup of dwarf mistletoe. This would eliminate the most common site for canker development. There has been far more experience and success in controlling dwarf mistletoe than Cytospora canker.

B. Avoid any activities that damage or weaken firs, especially logging injury.

C. Avoid sudden exposure of understory firs to strong light and high temperatures.

D. Do not plant firs on poor sites or sites not suitable for the species.

5. **Integrate Management Actions.**

The above options are not independent of each other but are normally incorporated into an overall management approach. Any combination of these may end up being selected (or rejected) depending on the objectives for specific forest stands.

PEST BIOLOGIES

Annosus Root Disease In True Fir

Heterobasidion annosum (formerly Fomes annosus) is a fungus that attacks a wide variety of woody plants. All western conifer species are susceptible. Madrone and a few brush species (Arctostaphylos spp. and Artemisia tridentata) are occasional hosts. Other hardwood species are apparently not infected. The disease has been reported on all the National Forests in California, with incidence particularly high on true fir in northern California campgrounds. Incidence is somewhat higher in older, larger fir stands and in stands with high basal areas (over about 330 square feet/acre).

During periods favorable to the fungus, fruiting bodies (conks) form in decayed stumps, under the bark of dead trees, or under the duff at the root collar. New infection centers begin by aerial spread of spores produced by the conks and subsequent colonization of freshly cut stump surfaces or wounds on living trees. The fungus then spreads through root contacts into the root systems of adjacent live true fir. Local spread of the fungus from a stump typically results in the formation of a disease center, with dead trees in the center and fading trees on the margin. These centers usually continue to enlarge until they reach natural barriers such as stand openings or non-susceptible plants.

In pines, H. annosum grows through root cambial tissue to the root crown where it girdles and kills the trees. In less resinous species such as true firs, the fungus sometimes kills trees, but more frequently it is confined to the heartwood and inner sapwood of the larger roots where it causes a chronic butt and root decay and growth loss. Thus, while infection in true fir usually does not kill the host, it does affect its growth and thriftiness. Losses in true fir from H. annosum are mainly the result of windthrow because of root decay, and reduced root systems that predispose trees to attack and eventual death by the fir engraver beetle. Field observations suggest that vigorous young firs are usually able to regenerate root tissues faster than they are lost to the root disease. But when true firs slow in growth because of stand and/or site conditions, root development decreases to where there is a net loss in roots and the trees slowly decline due to the gradual loss of their root systems. This decline may take 10 to 20 years before tree death occurs.

There are two pathogenic strains of the fungus that differ in their ability to infect various conifers in California. The "P" or pine type infects and kills all pines (although susceptibility of pine species vary), in addition to incense-cedar and western juniper. The "S" or fir type infects true fir and giant sequoia. Ah this time it is not certain which strain attacks Douglas-fir. Knowing which type is active in a stand will allow favoring alternate conifer species since the fungus strains do not cross infect between the two groups listed above.

Red Fir Dwarf Mistletoe

Red fir dwarf mistletoe, Arceuthobium abietinum f. sp. magnificae, is a seed-bearing plant that parasitizes only red fir. It will not survive without living host tissue, which it depends on for support, food, nutrients, and water.

Dwarf mistletoes initiate their life cycle when a seed lands on a needle or small twig of a host. The seed is coated with viscin, a sticky substance that allows it to adhere to the host tissue. During rains, the viscin becomes mucilaginous, allowing the seed to slide down to the needle base where it may lodge. The seed germinates in the winter or spring and the radicle grows along the twig until it reaches a needle base or bark irregularity. The radicle forms a holdfast and penetrates the twig into the xylem. A type of root system then develops in the twig. In 3 to 5 years from seed deposition, most successful infections will appear as branch swellings and will bear mistletoe shoots. These shoots will not produce fruit until at least 5 years following seed deposition, the average being 8-9 years. Fruit mature in the fall and disseminate seed in September and October. The seeds are explosively discharged from the fruit through the buildup of turgor pressure. Seeds normally have an upward trajectory.

Red fir dwarf mistletoe does not spread rapidly following establishment. Vertical spread in a tree averages less than 3 inches per year. Horizontal spread in a stand without overstory infection is also quite limited. The dense foliage of red fir limits spread because of the high probability of interception of the seed. Spread from infected overstory to understory may be up to about 100 feet, but it is usually less; the actual distance is dependent on slope, wind, and other factors. Trees less than 3 feet tall have a very limited chance of infection because of their small target size.

Fir Engraver

The fir engraver (Scolytus ventralis) attacks both white and red fir in California. Trees ranging in size from large saplings to overmature sawtimber are susceptible. Attacks can cause patch-killing of cambium along the bole, top-kill, or tree death. Top-kill or death occur most often in firs that have been weakened by root disease, dwarf mistletoe, overstocking, soil compaction, sunscald, logging injury, or drought. The fir engraver also breeds in slash and windthrown trees.

The fir engraver usually completes its life cycle in one year, sometimes two. Adults fly and bore into trees or green fir slash from June to September; larvae, pupae, and adults over-winter under the bark. Pitch tubes are not formed as they are with pine bark beetles; the usual evidence of attack is boring dust in bark crevices along the trunk and pitch streamers on the mid and upper bole. Trees colonized early in the summer may begin to fade by early fall, but those colonized later in the year usually do not fade until the following spring or summer, often after the beetles have emerged.

Cytospora Canker

Cytospora abietis is a canker-causing fungus that infects true firs throughout their range in California. It is a weak parasite, and usually attacks trees that have been weakened by disease, drought, fire, insects, or human disturbance. It is most commonly associated with dwarf mistletoe infection, and sometimes attacks as many as a quarter of the mistletoe bearing branches, killing many each year. The bright red flags of recently killed branches on dwarf mistletoe infected red firs are almost always the result of lethal Cytospora infections. C. abietis occasionally reaches especially damaging proportions in certain years, and may attack trees of any age, sometimes killing the tops or all of young trees.

Dwarf Mistletoes (Appropriate for Lodgepole pine dwarf mistletoe)

Dwarf mistletoes (Arceuthobium spp.) are parasitic, flowering plants that can only survive on living conifers in the Pinaceae. They obtain most of their nutrients and all of their water and minerals from their hosts.

Dwarf mistletoes spread by means of seed. In the fall the fruit ripen and fall from the aerial shoots. The seeds are forcibly discharged. The seed is covered with a sticky substance and adheres to whatever it contacts. When a seed lands in a host tree crown, it usually sticks to a needle or twig, where it remains throughout the winter. The following spring the seed germinates and penetrates the twig at the base of the needle. For the next 2-4 years, the parasite grows within the host tissues, developing a root-like system within the inner bark and outer sapwood, and causing the twig or branch to swell. Aerial shoots then develop and bear seed in another 2-4 years.

Dispersal of dwarf mistletoe seeds is limited to the distance the seeds travel after being discharged. From overstory to understory, this is usually 20 to 60 feet, but wind may carry them as far as 100 feet from the source. A rule of thumb is that the seeds can travel a horizontal distance equal to the height of the highest plant in an infected tree. There is some evidence that long distance spread of dwarf mistletoe is occassionally vectored by birds and animals.

Vertical spread within tree crowns of most dwarf mistletoes is limited to less than one foot per year because of foliage density. Because of the thin crowns of Digger pine, however, the vertical rate of spread has been measured as being greater than 2 feet per year. This rate of spread equalled or exceeded the rate of height growth of infected trees.

Dwarf mistletoes are easy to identify because they are generally exposed to view within a tree's crown. Signs of infection include the yellow-green to orange mistletoe plants, basal cups on a branch or stem where the plants were attached, and detached plants on the ground beneath an infected tree. Symptoms include spindle-shaped branch swellings, witches' brooms in the lower crown, and bole swellings.